Chapter 3
Farmers' Behavior for Introducing Livestock to Respond to External Shocks

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Abstract The purpose of this chapter is to reveal factors to introduce or raise livestock by farmers to respond to external shocks such as rapid economic growth with globalization and extreme weather events. Risk behaviors of farmers, social networks, and credit constraints are considered the main factors in this chapter. The target research area is the northern part of Vietnam around the Red River Delta. The villagers have a traditional home garden system, the so-called VAC, comprising trees for fruit, ponds for aquaculture, and livestock with high resilience. Because of the intrusion of the market economy, the traditional system is collapsing, although livestock can be considered a method to make smooth consumption in response to shocks. This chapter indicates that farmers in the targeted communities are coping with the intrusion of the market economy as an external shock. Raising livestock to generate a profit in the market has gained greater focus. Larger inputs for livestock may have caused environmental degradation and must be examined. Raising livestock is one of the major methods to enhance the resilience of households through smoothing consumption. However, it is probably causing other unexpected problems in the area because of the loss of the stability of the traditional VAC system.

Keywords VAC system · Traditional knowledge · Resilience · Biological production system

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3.1 Raising Livestock to Enhance Resilience in Developing Countries

It is commonly understood that low-income households in developing countries encounter the risk of income variation and consumption variation caused by income variation because of imperfect markets, particularly in those lacking perfect financial markets.[1] The ability to smooth consumption under external shocks to income is very important for households in developing countries under those circumstances. Assets for agricultural production such as livestock, land, grain, and human capital are used, frequently, for consumption smoothing by households in developing countries without accessing to financial organizations when encountering external shocks.[2] Livestock is one of the major measures for consumption smoothing. Markets in many countries in Southeast Asia have matured to approach perfect markets with economic growth in recent years. Farmers in those countries have opportunities to generate income by selling their products, which contributes to income smoothing. It also provides measures for consumption smoothing. Vietnam, which is the main research target in this chapter, has also experienced rapid economic development like other countries in Southeast Asia since the late 1980s by implementing Doi Moi. They have traditional home garden systems similar to Indonesia and Sri Lanka, which is called the VAC system. The typical VAC system comprises trees for fruit (Voun), ponds for aquaculture (Ao), and livestock (Chuong). This system is effective for consumption smoothing as households rely heavily on self-consumption, which means opportunities to generate income and measures for income smoothing are limited. In addition, this VAC system is rather small; not only the inputs for the system but also the outputs along with the by-products from the system do not affect the environment. The traditional VAC system has been

[1]There are many previous studies concerning income and consumption smoothing under external shocks: for instance, Ligon and Schecter (2002, 2003), Ito and Kurosaki (2007), Jalan and Ravallion (2001), Kurosaki and Fafchamps (2002), and Kurosaki (1995).

[2]Liquidity among those assets is different. Sure, holding high liquidity assets is critical for the households to respond to external shocks. Liquidity of assets for agricultural production is not so high in some cases. Moreover, values of those assets tend to be decreased because of external shocks affecting the area overall, including extreme weather event. Under those circumstances, consumption smoothing by using those assets is not workable. Farmers encountering external shocks prefer to hold livestock rather than to sell the livestock in many sub-Saharan African countries (Fafchamps et al. 1998, Hoddinott 2006 and Kurosaki 2009).

considered a rather highly resilient system from the perspective of those features. The traditional VAC system is undergoing transformation because of rapid economic growth with globalization, which can be considered as external shock. Resilience of farmers is consumption smoothing to respond to those external shocks. Farmers are allowed to access the market to make profits so that they may obtain income, for which the highest liquidity assets are the most effective for consumption smoothing. Particularly, they have an incentive to introduce livestock because the developing market is not sufficient to provide perfect liquidity for income and consumption smoothing, and they are able to cope with frequent, extreme weather events. Livestock have a high affinity to VAC; however, livestock raised in recent years is rather commercialized. Knowledge of feeding technology for the livestock and access to markets are needed to make profits in order to introduce the livestock. Therefore, a leading farmer must take risks to feed the livestock and have access to inputs with credit to purchase it. Farmers are able to obtain those through social networks in the community, which is also an important asset in developing countries.

The purpose of this chapter is to reveal factors to introduce or raise livestock by farmers to respond to external shocks such as rapid economic growth with globalization and extreme weather events. Risk behaviors of farmers, social networks, and credit constraints are considered the main factors in this chapter. The target research area is the northern part of Vietnam around the Red River Delta. An overview of the research area is provided in the next section followed by a section discussing the theory of risk behavior proposed by Binswanger. That is followed by a section where estimation is implemented and the estimation results are presented. This chapter is summarized in the final section.

3.2 Overview of Research Area

Household surveys have been conducted in three communities, Giao Long, Giao Thien, and Giao Xuan, located in the Red River estuary in the northern part of Vietnam. One hundred forty-nine households in Giao Long, 150 households in Giao Thien, and 151 households in Giao Xuan have been covered from December 3–22, 2012, from January 22–29, 2013, and from January 14–21, 2013, respectively. Of course, basic information about the households in addition to detailed information about agricultural production, aquaculture, and related information have been mainly collected through the questionnaire surveys. In addition to that information, risk preferences, credit constraints, and social network information have also been collected. In particular, some types of data, including agricultural production, were queried for 2000–2012 very carefully to create a sort of panel data.

The population in 2010 in those three communities was 7672 (Giao Long), 9486 (Giao Thien), and 9232 (Giao Xuan).[3] It is recognized that there is a decreasing

[3]These data and the following data related to paddies and livestock were obtained from several institutions through field surveys.

population in those three communities when comparing those with the population figures for 2005, 8362 (Giao Long), 10,286 (Giao Thien), and 9486 (Giao Xuan). However, the number of households has increased or remained stable from 2005 to 2010: a total of 2503 in 2005 compared to a total of 2511 in 2010 in Giao Long, 2317–2646 in Giao Thien, and 2466–2732 in Giao Xuan. It is implied that the number of households has increased because of economic activities including agriculture developing in a dynamic way, but average household size has decreased. It is observed in the field that farmers cannot help facing changes in their lifestyle including agricultural production to respond to the surging market economy.

Figure 3.1 indicates the trend in average land productivity of paddies from 2000 to 2012 from field survey in 2012 and 2013. Productivity changes have been caused by idiosyncratic reasons and aggregate shocks, and the main reasons for aggregate shocks are extreme events such as drought, floods, and insect infestation. Remarkable decreasing land productivity in paddies can be found for 2005, 2009 and 2012 in the figure.[4] It may be noted that the frequency of those extreme events has increased as well as severity of those events. Rice production is the major farming activity in almost all Asian countries. Vietnam is one of the largest exporters of rice in Asia with Thailand because the government of Vietnam implements policies to enhance the productivity of rice. Rice production supports basic food intake of the

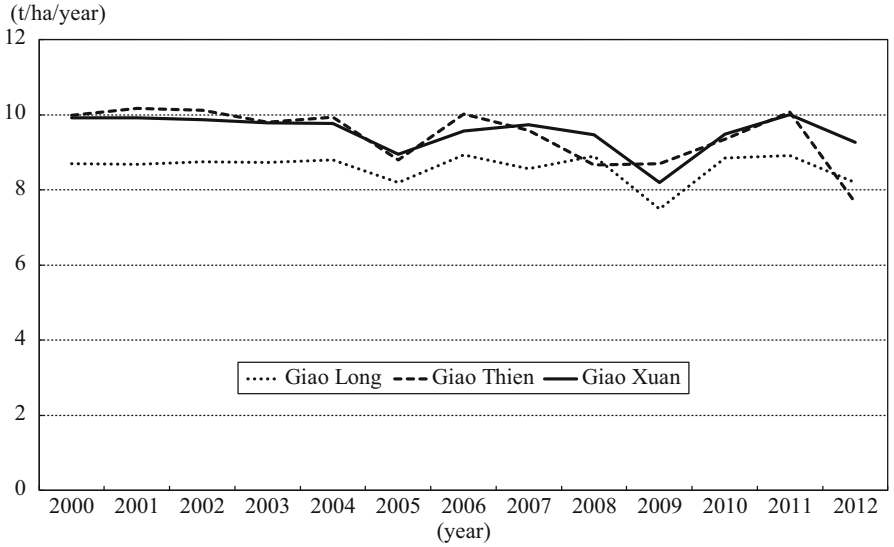

Fig. 3.1 The trend in average land productivity of paddies (2000–2012) (Source: Field Survey 2012 and 2013)

[4]The data in Fig. 3.1 are from a questionnaire survey. Findings mentioned are justified from interviews with experts such as government officials.

household. Almost all households engaged in farming have VAC system with paddy field. VAC system with rice production enhances resilience of the household.

Farmers in those three communities have introduced livestock under conditions of both the surging market economy and extreme events. Table 3.1 show raising livestock in research communities. While production in the paddies in the three communities has not varied widely, situations of raising livestock in those communities have done so. The number of cattle and buffalo increased remarkably in Giao Xuan although the trend in the number of cattle and buffalo in both Giao Thien and Giao Xuan remained almost the same. The numbers of pigs increased in all three communities. However, their numbers in both Giao Long and Giao Thien remained rather more stable than in Giao Xuan. The numbers decreased greatly in Giao Xuan. The amount of the production of poultry had increased in all three communities. The numbers of cattle and buffalo in Giao Long was much smaller than those in the two other communities. Poultry was raised in all three communities and was increasing in a stable manner. It is recognized that they for the most part raised larger animals, such as cattle and buffalo, which require certain specific skills, land, and feed. Information and credit are thus necessary. That means that a farmer who would like to raise larger animals has to be prepared to take risk. Farmers in Giao Xuan had increased the number of cattle and buffalo raised and had to decrease the number of pigs raised. Farmers in the two other communities preferred pigs to cattle and buffalo as seen from the rather stable number of pigs raised. The number of cattle raised in Giao Long was much less than in the two other communities. It is noted from Table 3.1 that farmers in those three communities decided on the types of livestock to introduce into their farming systems based on considering information about skills, the capacity of the land, and finances, including the possibility of obtaining formal/informal credit based on the production of paddies and poultry. Farmers in Giao Xuan tend to take more risk than farmers in the two other

Table 3.1 Raising livestock in targeted research communes

Commune/Year		2006	2007	2008	2009	2010
Giao Long	Cattle/Buffalo (Number)	120	70	100	69	61
	Pig (Number)	3680	3650	2875	3008	3417
	Production of poultry (t)	278	332	454	508	588
Giao Thien	Cattle/Buffalo (Number)	273	308	218	154	174
	Pig (Number)	4352	4520	4504	4120	3813
	Production of poultry (t)	278	356	417	419	444
Giao Xuan	Cattle/Buffalo (Number)	47	313	250	171	192
	Pig (Number)	4050	4120	2837	2890	2501
	Production of poultry (t)	304	401	495	497	526

Source: Field Survey 2012 and 2013

communities. The least risk takers among the three communities are found in Giao Long. The case of Giao Thien lies in between Giao Xuan and Giao Long.

3.3 Risk Behaviors of Farmers

3.3.1 Theoretical Framework of Risk Behaviors of Farmers

The framework proposed by Binswanger (Binswanger 1981, 1980, 1978a, b, and Miyata 2003) is applied for this study to capture risk attitudes of farmers in all three communities. Binswanger established an experimental method in the field to capture a partial relative risk aversion proposed by Menezes and Hanson (1970) and Zeckhauser and Keeler (1970).

W represents the expected final wealth and is defined as follows:

$$W = f\ddot{O} + M \tag{3.1}$$

$f\ddot{O}$ is initial wealth, and M is prospect of new wealth. This definition is from prospect theory proposed by Kahneman and Tversky (1979) to explain more realistic decisions under uncertainty. An individual utility function is represented by $U(W) = U\left(f\ddot{O} + M\right)$. Relative risk aversion (PRA) is calculated as follows, when Q represents absolute risk aversion (ARA: Pratt (1964)):

$$\text{PRA} = -W\frac{U'}{U''} = WQ \tag{3.2}$$

U' and U'' are the first derivative and second derivative of the utility function, respectively. PRA in this framework is allowed to be changed so that the heterogeneity of individual persons or households may be captured although PRA is assumed not to decrease (Arrow (1971)) and remains constant, which is called constant relative risk aversion (CRRA). Kessler and Wolff (1991) and Zhang and Ogaki (2000) indicate a decreasing PRA. A partial risk aversion (PRRA) is represented from PRA as follows:

$$\text{PRRA}(\omega + M) = -M\frac{U'(\omega + M)}{U''(\omega + M)} \tag{3.3}$$

As is seen from (3), *PRRA* captures the risk attitude when the prospect of new wealth M is changed with constant initial wealth ω. From (2) and (3), the relationship among three types of risk aversions is shown below:

$$\mathrm{RRA} = \omega \mathrm{ARA} + \mathrm{PRRA} \tag{3.4}$$

This relationship indicates that RRA is able to increase as PRRA is increasing while assuming a constant ARA and increases in the prospect M although RRA is assumed to be generally constant.

3.3.2 Measuring Risk Behaviors of Farmers

We designed a game for hypothetical investment to estimate partial risk aversion in the research area.[5] Table 3.2 shows the game for hypothetical investment used in the field. Four types of the game are provided in total. Differences among those four games indicate initial investment and payoffs. For *Games* 1, 2, 3, and 4, 2000 VND, 10,000 VND, 20,000 VND, and 200,000 VND are indicated, respectively. Each game has five scenarios for both cases of failure and success, of which the probabilities are the same: 50% for failure and 50% for success. Farmers targeted in the survey are requested to choose one business type or payoff. In the case of *Game* 1, farmers are supposed to invest 2000 VND for one game while considering each type of payoff. If the farmer chooses business type 2, he/she is expected to earn 240,000 for success of the investment with 50% probability and 50% probability for failure of the investment at 80,000. Business types 1, 2, 3, and 4 are considered "extreme risk aversion," "severe risk aversion," "moderate risk aversion,"

Table 3.2 Game for hypothetical investment

Game 1. Initial investment cost is: 2000 VND Game 2. Initial investment cost is: 10,000 VND **Payoff for Investment Game 1 & 2**					
Business type	1	2	3	4	5
Fail (VND)	100,000	80,000	60,000	40,000	0
Succeed (VND)	100,000	240,000	300,000	320,000	600,000
Game 3. Initial investment cost is: 20,000 VND Game 4. Initial investment cost is: 200,000 VND **Payoff for Investment Game 3 & 4**					
Business type	1	2	3	4	5
Fail (VND)	200,000	160,000	100,000	40,000	0
Succeed (VND)	200,000	340,000	600,000	660,000	1,000,000

[5] A constant risk aversion (CRA) utility function is assumed in this research as follows (Binswanger (1981), Binswanger (1980), Binswanger (1978a), Binswanger (1978b), and Miyata (2003)).

$$\mathrm{U} = (1 - S)M^{1-S}$$

"inefficient risk aversion," and "neutral to negative risk aversion," respectively, because of the expected utility from expected income and partial according to a series of study of Binswanger (Binswanger 1981, 1980, 1978a, b) and Miyata (2003). *Game* 4 is seen as "inefficient risk aversion" because the expected payoff of *Game* 4 is the same as that of *Game* 3 but the variance is larger.

Figure 3.2 shows the distribution of the number of farmers for each chosen payoff type and risk aversion type. The number of farmers who chooses moderate

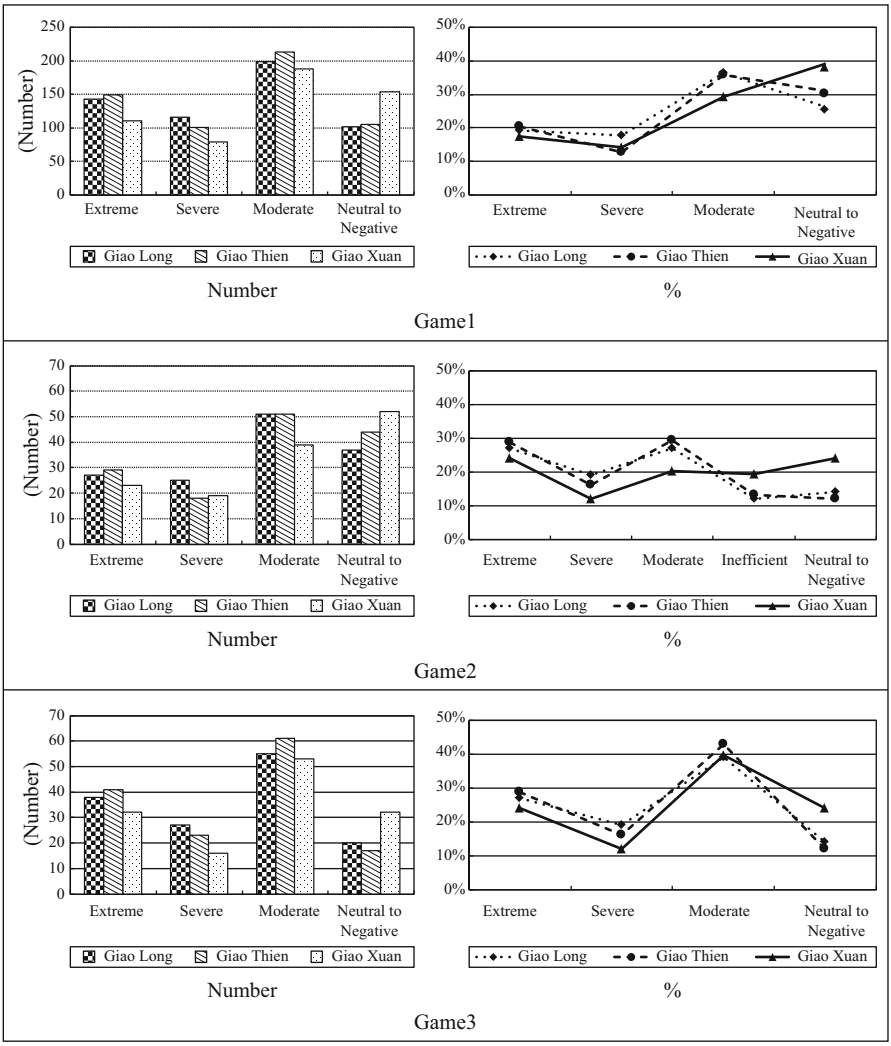

Fig. 3.2 Distribution of the number of farmers for each chosen payoff type (Source: Field Survey 2012 and 2013. Note: Extreme, severe, moderate and neutral to negative on the figure indicate "extreme risk aversion," "severe risk aversion," "moderate risk aversion," "inefficient risk aversion," and "neutral to negative risk aversion," respectively)

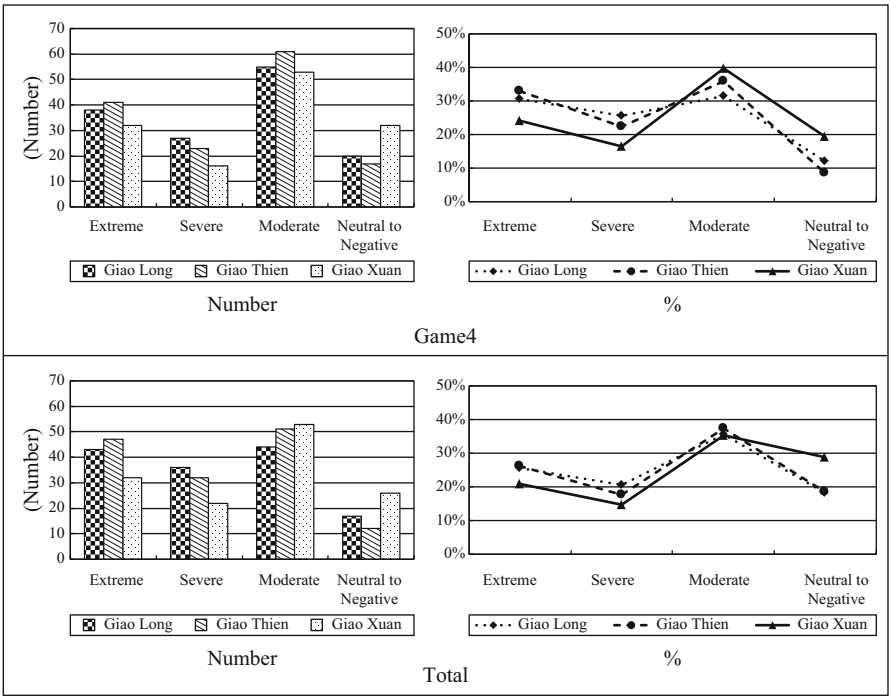

Fig. 3.2 (continued)

risk aversion including inefficient risk aversion or the ratio of them is found in almost all cases. In addition, the number of farmers who chose it and the ratio of them in Giao Xuan are larger than in the two other communities when neutral to negative risk aversion cases are focused on in each game. The tendency is found that farmers prefer to take risk in Giao Xuan as the number of farmers who choose extreme and severe risk aversions and the ratio of them there are smaller than in the two other communities. Taking risks by farmers in Giao Long is rather larger than that in Giao Thien, if it must be, although it is difficult to note the differences in risk preferences for the two other communities. The number of farmers who take more risk and the ratio of them decrease as the game proceeds. It is seen that they become afraid of losing rather large amounts of money with larger initial investment although the games are only hypothetical.

3.3.3 Factors of Risk Behaviors of Farmers

The ordered probit model is employed to identify factors to define types of risk aversions in each game. The estimation equation is shown below. y_i is an ordinal variable, which is the chosen business type by the farmer in this study:

$$y_i^* = x_i\beta + e_i$$
$$e_i \tilde{} N(0,1), \forall i = 1, \ldots, N$$
$$y_i = j, \mu_{j-1} < y_i^* \leq \mu_j$$

The results of the estimation are indicated in Table 3.3 with an explanation of the variables included in the estimations. *Age* is the age of respondent, and its expected sign can be either positive or negative. *Sex* is a dummy variable, which is assigned a value of 1 for male. *Native* is a dummy variable, which is assigned a value of 1 for the respondent having been born in the commune. The sign of the coefficient of

Table 3.3 Estimation results of factors of farmers' risk behaviors

Variable ID		Game 1	Game 2	Game 3	Game 4
Age	*Age of respondent*	−0.004	−0.004	0.000	0.005
		(0.530)	(0.500)	(0.050)	(0.640)
Sex	*1 if respondent is female*	−0.144	−0.188	−0.220	−0.280
		(0.700)	(0.920)	(1.080)	(1.360)
Edu	*Year of education*	0.014	0.007	0.064*	0.070**
		(0.390)	(0.180)	(1.720)	(1.880)
Native	*1 if respondent is born in the village*	−0.140	−0.426*	−0.290	−0.276
		(0.580)	(1.760)	(1.200)	(1.130)
Paddy_area	*Area of paddy field*	0.000	0.000**	0.000**	0.000***
		(1.580)	(2.250)	(2.140)	(2.740)
Network	*Number of acquaintances to ask about farming (maximum number is five)*	−0.081	−0.080	−0.160**	−0.170**
		(1.120)	(1.060)	(2.140)	(2.340)
Variety_animal	*Variety of animals in the household*	0.265**	0.102	−0.050	−0.089
		(2.310)	(0.900)	(0.450)	(−0.780)
d_gx	*Dummy variable of Giao Xuan*	0.559*	0.607**	0.572*	0.813***
		(1.800)	(1.960)	(1.830)	(2.600)
d_gt	*Dummy variable of Giao Thien*	0.209	0.174	0.028	0.082
		(0.700)	(0.590)	(0.090)	(0.270)
Obs		160	160	160	160
Log likelihood		12.75	13.17	15.92**	21.11**
Psudo R2		0.03	0.03	0.04	0.051

Note:
1. Absolute value of z-statistics in parentheses
2. *significant at 10% level; **significant at 5% level; ***significant at 1% level

native can be either positive or negative. It is possible to take risk or avoid risk because they have much knowledge of the area. *Paddy_area* is the area of paddy field. Its expected sign is positive because it is an asset of the household, so it may allow the people in the household to take risk. *Network* is the number of acquaintances to ask about farming, which is at most five. This variable is a sort of indicator of social capital. In addition, varieties of information sources reflected by this variable may support farmers to introduce new agricultural technology including new varieties, plants, and livestock. Therefore, the sign of *network* is expected to be positive. *Variety_animal* is the number of varieties of the animals raised by the household. The meaning of this variable is the same as *paddy_area*. Moreover, livestock is considered a measure of consumption smoothing (Jalan and Ravallion 2001 and Kurosaki 1995). The expected sign of *variety_animal* is positive. Variables *d_gx* and *d_gt* are dummy variables for Giao Xuan and Giao Thien, respectively.

Looking at the results in Table 3.3, it is found that *edu*, *native*, *paddy_area*, *network*, *variety_animal*, and *d_gx* are significantly different from 0 in the result of at least one game. The results of *edu* are consistent with hypothesis although only two results, *Game* 3 and *Game* 4, are positive and significantly different from 0. A result of *native* for *Game* 2, only, is negative and significantly different from 0. All the results of *paddy_area* except for *Game* 1 are positive and significantly different from 0, which are consistent with expected result. The results of *network* are negative and significantly different from 0 for *Game* 3 and *Game* 4. The expected sign of *network* is positive as farmers are assumed to obtain information of new agricultural technology, method of cultivating and fostering livestock, status of market, and other areas related to agriculture easily. However, the signs of *network* are negative. It is observed from the field survey, including interviews, that farmers who may be considered leasing farmers are rather independent and do not rely on other farmers. Conversely, followers rely on such networks. It appears that the signs of the results of *network* are negative from this sort of circumstance. *Variety_animal* is expected to be positive and significantly different from 0 as is *paddy_area*, but the estimation results show the results being as expected only in the case of *Game* 1. Dummy variables *d_gx* and *d_gt*, in order to ascertain character difference of two communities, Giao Thien and Giao Xuan, from Giao Long show that only *d_gx* is positive and significantly different from 0. The numbers of cattle and buffalo raised have increased in Giao Xuan as indicated in Table 3.1. It may be considered that farmers in the commune take more risk than those in the other communities.

3.4 Factors of Introducing Livestock

Factors of deciding livestock to raise are estimated in this section. Estimation for panel data is intended to be employed. Several variables are added to the variables used for ordered probit model to estimate the factors' relationship with risk chosen

by farmers in section 9.3. *Yield_Paddy* and *Credit* are added. *Yield_Paddy* means the yield of the paddy during the year, and *Credit* means experience of constraints for access to credit, such as borrowing money from formal and informal money lenders. The definition of credit constraints or capturing experience of constraints for access to credit is implemented by applying the direct-elicitation method (DEM: Feder et al. 1990: Petrick 2004 and Scott 2000). The expected signs for the coefficients of the variables are the same as in the estimation for factors for risk behaviors of farmers by using ordered probit model in section 9.3. The expected signs of the added variables, *Yield_Paddy* and *Credit*, are positive and negative, respectively, because *Yield_Paddy* increases the profit from farming, which makes farmers invest in livestock, and *Credit* indicates that farmers do not have enough resources to invest in livestock. Farmers are asked whether they raised the livestock, which are cattle, buffalo, pig, poultry, duck, rabbit, and others for 12 years, from 2000 to 2012, to build panel data. Obtained information of raised animals are categorized into four, which are "cow," including cattle and buffalo; "pig"; "poultry," including chicken and ducks; and "others," including rabbits and others. Because the risk behaviors of farmer are captured through the game, we are unable to build panel data for the risk behaviors of farmer. Therefore, the estimated results of the ordered probit model to estimate factors of the risk behaviors of farmer, particularly *edu*, *paddy_area*, and *d_gx*, are used to estimate the risk behaviors of farmers for each year to complete the panel data. *Game i*, $i = 1, 2, 3, 4$, is the observed risk behavior from the questionnaire survey, and the estimated risk behavior uses the results of estimating the factors of the risk behaviors of farmers.

A panel logit model is employed to estimate the factors of introducing or raising livestock by farmers. Binary data for four categorized livestock, cow, pig, poultry, and others, is a dependent variable. Both fixed effect and random effect models are employed for the estimation:

$$\begin{aligned} y_{it}^{*} &= X_{it}\beta + v_{it} + u_i \\ y_{it} &= 1 \quad if \quad y_{it}^{*} > 0, and\ 0\ otherwise \end{aligned}$$

Fixed effects model: $Cov(u_i, X_{it}) \neq 0$

$$\Pr[y_{it} = 1] = \Pr\left[y_{it}^{*} > 0\right] = \Pr\left[v_{it} > -X_{it}'\beta - \mu_i\right] = F\left(X_{it}'\beta + \mu_i\right)$$

Random effects model: $Cov(u_i, X_{it}) = 0$

$$\Pr[y_{it} = 1] = \Pr\left[y_{it}^{*} > 0\right] = \Pr\left[v_{it} + \mu_i > -X_{it}'\beta\right] = F\left(X_{it}'\delta\right)$$

Tables 3.4a, 3.4b, 3.4c, 3.4d, 3.4e, 3.4f, 3.4g, and 3.4h shows the results of the estimation. The id number of the result of the estimation on the top of the table includes the types of the game. The result of *Game i* on id number of the results of estimation (1) means observed risk behavior through questionnaire survey and estimated risk behavior by using the results of estimating the factors of risk behavior of farmers for *Game 1*.

Table 3.4a Estimation results of introducing livestock: cow, fixed effect

	(1)	(2)	(3)	(4)
Area_Paddy	-5E-05	-1E-05	-4E-05	-2E-05
	(0.400)	(0.850)	(0.380)	(0.150)
Yield_Paddy	−0.015	−0.020	0.001	0.007
	(0.340)	(0.450)	(0.020)	(0.160)
Age	−0.008	−0.011	−0.005	−0.005
	(0.790)	(1.140)	(0.470)	(0.550)
Sex	0.212	0.217	0.110	0.081
	(0.930)	(0.960)	(0.490)	(0.360)
Edu	−0.073*	−0.074*	−0.088**	−0.093**
	(1.650)	(1.700)	(1.990)	(1.980)
Credit	−0.330	−0.333	−0.270	−0.258
	(1.560)	(1.570)	(1.280)	(1.220)
Network	−0.025	−0.019	−0.018	−0.024
	(0.230)	(0.180)	(0.170)	(0.220)
Game i	1.905***	2.173***	0.467**	0.124
	(2.850)	(3.140)	(1.990)	(0.700)
d_gx	0.877*	0.815*	0.467**	1.093**
	(1.830)	(1.710)	(1.990)	(2.240)
d_gt	1.982***	1.980	0.467**	2.199***
	(4.290)	(4.310)	(1.990)	(4.680)
Obs	4715	4715	4715	4715
Log likelihood	−418.39	−414.43	−428.95	−430.94
LR chi^2	88.36***	96.28***	67.25***	63.25***
Hausman chi^2	−0.16	−0.28	−0.19	−0.17

Note:
1. Absolute value of z-statistics in parentheses
2. *significant at 10% level; **significant at 5% level; ***significant at 1% level

When results of the Hausman test, which is a test to compare the desirability of the fixed effects model versus the random effects model, are considered, only the case of the estimation result (4) of others is rejected, and all the other cases show the random effects model is desirable. The null hypothesis of the test is that the individual principle factor has no relationship with the dependent variable, tested by applying chi-squared test. The fixed effects model is rationalized if the null hypothesis is rejected.

The results for cows are almost the same whether with fixed effects or with random effects. *Edu* is negative and significantly different from 0. The expected sign of *edu* is positive. The estimation results for *Game i* are positive and significantly different from 0 in almost all cases except for *Game 4*. It means that bigger risk takers introduce cows. Farmers who raise larger livestock such as cows must consider taking risk because a larger amount of investment for the livestock is needed. It is difficult to obtain knowledge regarding raising livestock and the

Table 3.4b Estimation results of introducing livestock: cow, random effect

	(1)	(2)	(3)	(4)
Area_Paddy	-5E-05	-1E-04	-4E-05	-2E-05
	(0.400)	(0.850)	(0.370)	(0.150)
Yield_Paddy	−0.012	−0.018	0.003	0.008
	(0.290)	(0.410)	(0.070)	(0.200)
Age	−0.008	−0.011	−0.005	−0.005
	(0.830)	(1.150)	(0.520)	(0.570)
Sex	0.210	0.211	0.111	0.080
	(0.930)	(0.940)	(0.490)	(0.360)
Edu	−0.073*	−0.073*	−0.089**	−0.092**
	(1.660)	(1.690)	(2.010)	(1.990)
Credit	−0.330	−0.339	−0.267	−0.258
	(1.580)	(1.620)	(1.290)	(1.240)
Network	−0.025	−0.019	−0.019	−0.024
	(0.230)	(0.170)	(0.170)	(0.220)
Game i	1.907***	2.173***	0.467**	0.124
	(2.850)	(3.140)	(1.980)	(0.700)
d_gx	1.984***	1.983***	2.201**	2.211***
	(4.290)	(4.320)	(4.680)	(4.660)
d_gt	0.876*	0.814*	1.093**	1.110**
	(1.830)	(1.710)	(2.240)	(2.280)
Cons	−11.516***	−12.263***	−5.737***	−4.701***
	(4.190)	(4.370)	(5.500)	(5.370)
Obs	4715	4715	4715	4715
Log likelihood	−443.824	−439.874	−454.391	−456.3834
Wald chi2	50.920***	53.060***	53.710***	51.230***
Sigma_u	0.001	0.001	0.001	0.001
	(0.014)	(0.015)	(0.000)	0.014)
Rho	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)

Note:
1. Absolute value of z-statistics in parentheses
2. *significant at 10% level; **significant at 5% level; ***significant at 1% level

manner of selling the livestock, as the number of farmers who raise such larger animals remains limited. *d_gx* and *d_gt* are positive and significantly different from 0. Both communities are raising larger animals than Giao Long. It may be considered that both communities make larger profits and respond to a change in the market. Other variables are not significantly different from 0. *Edu* is also different from the expected results. Those results seeming to be affected by the number of farmers who raise larger animals remain limited.

Almost all estimated variables for pigs, by both fixed effects and random effects, have fallen line with the expected results. *Age* and *edu* are not significantly different

Table 3.4c Estimation results of introducing livestock: pig, fixed effect

	(1)	(2)	(3)	(4)
Area_Paddy	0.000***	0.000***	0.001***	0.000***
	(11.610)	(11.510)	(12.110)	(11.510)
Yield_Paddy	0.050	0.052	0.059***	0.059***
	(4.390)	(4.560)	(5.230)	(5.180)
Age	−0.003	−0.004	−0.004	−0.004
	(1.110)	(1.270)	(1.210)	(1.310)
Sex	0.471	0.463***	0.426***	0.430***
	(6.850)	(6.740)	(6.230)	(6.290)
Edu	−0.010	−0.012	−0.019	−0.025*
	(0.770)	(0.910)	(1.460)	(1.870)
Credit	−0.397***	−0.386***	−0.372***	−0.371***
	(6.110)	(5.960)	(5.770)	(5.750)
Network	0.051*	0.055**	0.056**	0.058**
	(1.860)	(1.980)	(2.040)	(2.120)
Game i	0.317***	0.226***	0.074***	0.094**
	(7.200)	(5.670)	(1.410)	(2.000)
d_gx	−1.075	−1.049***	−0.952***	−0.979***
	(13.450)	(9.860)	(9.110)	(9.210)
d_gt	−1.407***	−1.393***	−1.310***	−1.318***
	(10.100)	(13.320)	(12.740)	(12.780)
Obs	4715	4715	4715	4715
Log likelihood	−2823.397	−2834.379	−2850.13	−2849.104
LR chi^2	651.660***	629.690***	598.190***	600.240***
Hausman chi^2	2.170	0.270	−0.600	−3.670

Note:
1. Absolute value of z-statistics in parentheses
2. *significant at 10% level; **significant at 5% level; ***significant at 1% level

from 0, and the signs are not unexpected. Raising pigs may be considered a moderate farming strategy in terms of responding to the market to make a profit from observation in the field because it is not larger than cows, easier to feed than cows, and provides more profit than poultries. *Area_Paddy* and *Yield_Paddy* are positive and significant for both cases. *Area_Paddy* may be a security in ensuring access to credit. *Yield_Paddy* may also be a security in ensuring access to credit like *Area_Paddy*, but seems to play a role in securing working capital for farming, including raising livestock. Credit constraints have a negative impact on access to credit because *Credit* is negative and significantly different from 0. In addition, because *network* is positive and significantly different from 0, social networks support farmers to introduce or raise pigs. The estimation results of *network* for cows are insignificant. Farmers with entrepreneurship who raise cows do not rely on social networks, and they are considered to be taking risks at the forefront of the

Table 3.4d Estimation results of introducing livestock: pig, random effect

	(1)	(2)	(3)	(4)
Area_Paddy	0.000***	0.000***	0.000***	0.000***
	(11.570)	(11.460)	(12.060)	(11.460)
Yield_Paddy	0.046***	0.048	0.055***	0.055***
	(4.150)	(4.320)	(4.980)	(4.930)
Age	−0.002	−0.002	−0.002	−0.002
	(0.650)	(0.790)	(0.730)	(0.830)
Sex	0.464***	0.455***	0.419***	0.422***
	(6.770)	(6.650)	(6.140)	(6.200)
Edu	−0.008	−0.010	−0.017	−0.023*
	(0.610)	(0.740)	(1.290)	(1.720)
Credit	−0.411***	−0.401***	−0.386***	−0.385***
	(6.370)	(6.240)	(6.040)	(6.020)
Network	0.052*	0.055**	0.056**	0.058**
	(1.870)	(1.990)	(2.050)	(2.120)
Game i	0.321***	0.228***	0.077	0.095**
	(7.270)	(5.730)	(1.470)	(2.020)
d_gx	−1.068***	−1.042***	−0.943***	−0.970**
	(10.040)	(9.800)	(9.040)	(9.140)
d_gt	−1.409***	−1.394***	−1.310***	−1.318***
	(13.450)	(13.320)	(12.730)	(12.770)
Cons	−2.477***	−2.133***	−1.632***	−1.593***
	(4.190)	(8.490)	(6.330)	(6.860)
Obs	4715	4715	4715	4715
Log likelihood	−2866.543	−2877.735	−2877.735	−2892.761
Wald chi2	546.500***	530.520***	530.520***	503.880***
Sigma_u	0.000	0.000	0.000	0.000
	(0.007)	(0.007)	(0.007)	(0.008)
Rho	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)

Note:
1. Absolute value of z-statistics in parentheses
2. *significant at 10% level; **significant at 5% level; ***significant at 1% level

commune when considering the estimation results for pigs with those for cows. It is becoming popular to raise pigs to make larger profits in response to market conditions. Knowledge of raising pigs, including the way for trading them, has been accumulated in the commune. Then, even followers are able to raise them rather easily. Almost all estimation results for risk preference, *Game i*, with the exception of the case of *Game* 3 in random estimation results, are positive and significantly different from 0. Farmers taking more risk introduce and raise pigs. According to the estimation results, *d_gx* and *d_gt*, Giao Xuan and Giao Thien are

Table 3.4e Estimation results of introducing livestock: poultry, fixed effect

	(1)	(2)	(3)	(4)
Area_Paddy	0.000	0.000***	0.000***	0.000***
	(9.720)	(9.790)	(10.220)	(9.780)
Yield_Paddy	0.015	0.018	0.023**	0.020
	(1.250)	(1.450)	(1.840)	(1.610)
Age	0.000	0.000	0.000	0.000
	(0.140)	(0.090)	(0.100)	(0.110)
Sex	0.213***	0.198***	0.162***	0.186***
	(2.970)	(2.750)	(2.260)	(2.590)
Edu	−0.047***	−0.048	−0.048	−0.049*
	(3.400)	(3.550)	(3.550)	(3.510)
Credit	−0.239***	−0.227***	−0.213***	−0.221***
	(3.500)	(3.330)	(3.130)	(3.250)
Network	0.180***	0.179**	0.172**	0.177**
	(5.950)	(5.920)	(5.690)	(0.040)
Game i	0.118***	0.045	−0.128**	−0.002
	(2.750)	(1.110)	(2.230)	(0.040)
d_gx	−1.383***	−1.344***	−1.284***	−1.314***
	(11.120)	(10.820)	(10.560	(9.850)
d_gt	−1.218***	−1.187***	−1.136***	−1.159***
	(10.200)	(9.920)	(9.700)	(10.590)
Obs	4715	4715	4715	4715
Log likelihood	−2672.969	−2676.079	−2674.16	−2676.690
LR chi^2	388.780***	382.560***	386.400	381.340***
Hausman chi^2	−1.200	−3.410	4.210	−3.820

Note:
1. Absolute value of z-statistics in parentheses
2. *significant at 10% level; **significant at 5% level; ***significant at 1% level

introducing or raising pigs than is Giao Long. The number of cows in both Giao Xuan and Giao Thien has been increasing, while the number of pigs has been declining, as indicated in Table 3.1. Farmers in both communities are inferred to prefer raising cows to make larger profits, preferring higher risk. It may be considered that there are a rather large number of leading farmers who have responded to the market actively in those communities.

The estimation results for poultries for both the fixed effect and the random effect are almost the same as the estimation results for cows and pigs, but there are some points that are different from those of cows and pigs. *Yield_Paddy* is positive and significantly different from 0 in the cases of *Game* 3 for both the fixed effects and the random effects estimation. It is interpreted that *Yield_Paddy* may play a role in securing working capital for pigs. Considering the case of poultries, it may require less working capital to raise them. This may be reflected in the estimation

Table 3.4f Estimation results of introducing livestock: poultry, random effect

	(1)	(2)	(3)	(4)
Area_Paddy	0.000***	0.000***	0.000***	0.000***
	(9.720)	(9.780)	(10.210)	(9.770)
Yield_Paddy	0.015	0.018	0.022*	0.020
	(1.270)	(1.470)	(1.850)	(1.620)
Age	0.001	0.001	0.001	0.001
	(0.440)	(0.410)	(0.440)	(0.440)
Sex	0.207***	0.191***	0.155**	0.179**
	(2.890)	(2.670)	(2.170)	(2.500)
Edu	−0.045***	−0.047***	−0.047***	−0.048***
	(−3.330)	(−3.470)	(−3.460)	(−3.430)
Credit	−0.243***	−0.232***	−0.218***	−0.226***
	(−3.600)	(−3.440)	(−3.240)	(−3.360)
Network	0.180***	0.179***	0.172***	0.177***
	(5.950)	(5.910)	(5.690)	(5.830)
Game i	0.118***	0.044	−0.128**	−0.002
	(2.750)	(1.090)	(−2.230)	(−0.040)
d_gx	−1.381***	−1.342***	−1.282***	−1.312***
	(−11.110)	(−10.810)	(−10.540)	(−10.590)
d_gt	−1.219***	−1.187***	−1.137**	−1.160***
	(10.200)	(−9.920)	(−9.700)	(−9.850)
Cons	−0.199	0.049	0.530*	0.188
	(−0.750)	(0.190)	(1.930)	(0.770)
Obs	4715	4715	4715	4715
Log likelihood	−2716.757	−2719.885	−2717.952	−2720.479
Wald Chi2	320.000***	315.970***	321.440***	315.860***
sigma_u	0.001	0.001	0.001	0.001
	(0.010)	(0.010)	(0.010)	(0.010)
rho	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)

Note:
1. Absolute value of z-statistics in parentheses
2. *significant at 10% level; **significant at 5% level; ***significant at 1% level

results for poultries. The estimation results for *edu* are negative and significantly different from 0 in the case of the random effect estimation. It is not only true of the estimation results for poultries but also of others that the estimation results of *edu* are difficult to interpret. Further altering of estimation is needed from this perspective. The same results for *Credit*, *network*, *d_gx*, and *d_gt* are found with those of cows and pigs. Interesting estimation results for poultry are regarding risk preference, *Game i*. Only estimation results for both *Games* 1 and 3 are significantly different from 0. However, a farmer who prefers less risk, an extreme risk averter indicated at *Game* 1, introduces and raises poultries because the estimation results for *Game* 1 are positive. In the case of moderate risk preference, indicated in *Game* 3, the sign of the estimation results is negative. Those farmers do not prefer poultries. A farmer who takes more risk introduces and raises cows and pigs rather than poultries.

Table 3.4g Estimation results of introducing livestock: other, fixed effect

	(1)	(2)	(3)	(4)
Area_Paddy	0.000***	0.000***	0.000***	0.000***
	(5.280)	(5.260)	(5.140)	(5.300)
Yield_Paddy	−0.064***	−0.064***	−0.062***	−0.065***
	(3.540)	(3.540)	(3.450)	(3.590)
Age	0.021***	0.021***	0.021***	0.020***
	(4.990)	(4.990)	(4.980)	(4.980)
Sex	0.109	0.108	0.083	0.119
	(1.180)	(1.170)	(0.900)	(1.290)
Edu	0.015	0.015	0.016	0.012
	(0.840)	(0.830)	(0.920)	(0.640)
Credit	0.360***	0.361***	0.381***	0.354***
	(4.050)	(4.060)	(4.290)	(4.020)
Network	0.198***	0.198***	0.191***	0.201***
	(4.060)	(4.060)	(3.910)	(4.110)
Game i	−0.003	−0.006	−0.142**	0.041
	(0.050)	(0.110)	(2.000)	(0.640)
d_gx	1.696***	1.698***	1.740***	1.672***
	(8.460)	(8.440)	(0.200)	(8.320)
d_gt	2.059***	2.061***	2.093***	2.047***
	(10.730)	(10.700)	(0.191)	(10.740)
Obs	4715	4715	4715	4715
Log likelihood	−1799.729	−1799.724	−1797.77	−1799.521
LR chi^2	497.900**	497.910***	501.810***	498.310***
Hausman chi^2	−4.860	−3.440	−6.310	37.820***

Note:
1. Absolute value of z-statistics in parentheses
2. *significant at 10% level; **significant at 5% level; ***significant at 1% level

Other animals such as rabbits are also raised in the research field. The estimation results for others are almost the same, whether being with fixed effects or with random effects. *Area_Paddy* is negative and significantly different from 0 in all cases, which are different from the results for pigs and poultries. *Yield_Paddy* is also negative and significantly different from 0. These results are the opposite of the results for pigs. The estimation results for *Age* and *Sex* are positive and significantly different from 0 and insignificantly different from 0, respectively, while the estimation results for *Age* and *Sex* for pigs and poultries are insignificantly different from 0 and significantly different from 0. The results for *Credit* for others, which are positive and significantly different from 0, are different from those of pigs and poultries. The estimation results for *network* are positive and significantly different from 0. The parameters of *Game i* are not significant except in the case of *Game* 3, which are negative. The parameters of dummy variables, *d_gx* and *d_gt* for Giao

Table 3.4h Estimation results of introducing livestock: other, random effect

	(1)	(2)	(3)	(4)
Area_Paddy	-3E-04***	-3E-04***	-3E-04***	-3E-04***
	(5.210)	(5.180)	(5.070)	(5.230)
Yield_Paddy	−0.057	−0.057***	−0.055***	−0.058***
	(3.190)	(3.190)	(3.100)	(3.240)
Age	0.019***	0.019***	0.019***	0.019***
	(4.700)	(4.700)	(4.690)	(4.690)
Sex	0.118	0.117	0.092	0.128
	(1.280)	(1.270)	(0.990)	(1.390)
Edu	0.011	0.011	0.013	0.008
	(0.650)	(0.650)	(0.740)	(0.470)
Credit	0.373***	0.374***	0.393	0.367***
	(4.210)	(4.220)	(4.450)	(4.180)
Network	0.198***	0.198***	0.191***	0.201***
	(4.060)	(4.050)	(3.910)	(4.110)
Game i	−0.006	−0.008	−0.145**	0.039
	(0.100)	(0.150)	(2.050)	(0.620)
d_gx	1.680***	1.682***	1.723***	1.655***
	(8.390)	(8.380)	(8.630)	(8.250)
d_gt	2.052***	2.054***	2.084**	2.039***
	(10.700)	(10.670)	(10.900)	(10.700)
Cons	−4.306***	−4.300***	−3.928***	−4.400***
	(10.590)	(10.860)	(9.710)	(11.680)
Obs	4715	4715	4715	4715
Log likelihood	−1849.292	−1849.286	−1847.240	−1849.1
Wald chi2	294.680***	294.650***	296.010***	295.400***
Sigma_u	0.181	0.181	0.179	0.182
	(0.064)	(0.064)	(0.063)	(0.064)
Rho	0.010	0.010	0.010	0.010
	(0.007)	(0.007)	(0.007)	(0.007)

Note:
1. Absolute value of z-statistics in parentheses
2. *significant at 10% level; **significant at 5% level; ***significant at 1% level

Xuan and Giao Thien are positive and significantly different from 0 in all cases. Categorized livestock as other animals are rather small animals. It seems they are easier to raise than are larger animals such as cows and pigs. It is inferred from the estimation results that farmers who have experience of facing credit constraints and relying on networks prefer to raise those rather small livestock. In addition, their behaviors are not related to risk behavior, although it is found to be significantly different from 0 and negative. Those farmers must be small scale or not well commercialized.

Farmers raising livestock are large scale or favor making a profit in the market although the estimation results for cows with both the fixed effect and the random effect are not very clear because of the small number of cases, possibly not supporting that interpretation. Those farmers take risks and are not constrained by credit. With consideration of the differences in the estimation results of the yield of pigs from that of poultries, farmers who raise pigs favor the market more as it is inferred that they generate profit from their paddies. The land for paddies can be considered collateral, so the estimation results including it for both pigs and poultries are positive and significantly different from 0. While the estimated parameters for the yield of paddies for pigs are positive and significantly different from 0, those of poultries are not significantly different from 0 for all the cases, but except for, in *Game* 3, the rather risk preferred case. A positive relationship between raising pigs and the yield of paddies is found. Farmers who are able to achieve higher productivity of paddies favor making a profit from the paddies in the market and raising pigs. It is inferred that farmers who introduce or raise larger livestock such as pigs respond to the market economy to earn profits with a rather high-risk preference. Farmers with lower-risk preferences also raise smaller livestock such as poultries, etc. Those livestock may play a role in making their livelihood stable and may be related to the traditional VAC system. The estimated results for network are positive and significantly different from 0 in almost all cases. Social networks are an important factor to support the raising of livestock that is introduced for both reasons of making a profit in the market and of hedging risk. Information about livestock, including the manner of raising them, is disseminated through the social networks in the commune.

3.5 Summary

The purpose of this chapter is to reveal factors to introduce or raise livestock to respond to external shocks such as rapid economic growth with globalization and extreme weather events. Introducing the market economy is considered to have been an external shock to society. The villagers have a traditional home garden system, the so-called VAC, comprising trees for fruit, ponds for aquaculture, and livestock with high resilience. Because of the intrusion of the market economy, the traditional system is collapsing, although livestock can be considered a method to make smooth consumption in response to shocks. It is revealed in this chapter that farmers who favor making a profit from their agricultural products with rather high-risk preferences raise larger livestock such as cows and pigs. It is more difficult to raise larger livestock from the perspective of technology. Therefore, farmers who are risk lovers tend to introduce large livestock. The significance of networks is found in the estimation results. The technology for raising livestock as well as other information to respond to the introduction of the market economy is disseminated

through the social network the farmer belongs to. Followers who are rather risk averse are also able to obtain the information.

Farmers in the targeted communities are coping with the intrusion of the market economy as an external shock. However, it is probably causing other unexpected problems in the area because of the loss of the stability of the traditional VAC system. Raising livestock to generate a profit in the market has gained greater focus. Larger inputs for livestock may have caused environmental degradation and must be examined. Raising livestock is one of the major methods to enhance the resilience of households through smoothing consumption. Generating a profit from selling in the market can accomplish that. While raising livestock may enhance the resilience, both generally and specifically at the household level, it is causing other unexpected problems such as a new environmental degradation. A proper balance between inputs and outputs must be estimated at some level such as the commune (estimation results will be affected by the boundary of the estimation) if new technology and systems are introduced. Intrusion of the market economy in developing countries, including in the targeted area in this chapter, has become much faster. Farmers have an incentive to cope with it to generate profits. The situation causes us to encounter difficulties.

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